

Field Guide to

Non-chemical Pest Management



in Tomato Production

Pesticide Action Network (PAN) Germany



Field Guide to

Non-chemical Pest Management in Tomato Production

Pesticide Action Network (PAN) Germany
Hamburg, 2005

This publication is prepared by PAN Germany
for PAN UK.

Pesticide Action Network (PAN)

Founded in 1982, the Pesticide Action Network is an international coalition of over 600 citizens groups in more than 60 countries, working to oppose the misuse of pesticides and to promote sustainable agriculture and ecologically sound pest management.

PAN Germany was established in 1984 as part of this global network and has continually been involved in initiatives to reduce the use of hazardous pesticides and to promote sustainable pest management systems on national, European and global levels.

Acknowledgements

First, we want to express our gratitude to the universities and organisations that have given the permission to use their photos for the OISAT project. (For more details see p. 43)

We also wish to thank all the individuals, groups and organizations that have prepared the bases for the most control measures presented in this field guide, may it have been by preserving traditional experience, on field trials, on field research or in the lab.

Nernstweg 32, 22765 Hamburg, Germany
Phone: +49 (0) 40 – 399 19 10-0
Fax: + 49 (0) 40 – 390 75 20
Email: info@pan-germany.org
Internet: www.pan-germany.org
www.oisat.org

Prepared by: Dr. Jewel Bissdorf
Editor: Carina Weber
Layout: Reginald Bruhn

Hamburg, August 2005

Index

Prologue

Pesticides worth more than 30 billion US dollar are intentionally released into the global environment every year. A high proportion of these is highly toxic and has immediate adverse effects on human health, wildlife, local food sources such as cattle or fish, beneficial insects and biodiversity. Some of them have chronic effects including cancers, reproductive problems, birth defects, hormonal disruption and damage to the immune system. Impacts come from direct exposure in use, spray drift, washing work clothes used while spraying, home pesticide storage, pesticide dumps, and persistence in the environment.

Overall aim of the international *Pesticide Action Network (PAN)* is to eliminate the use of hazardous pesticides, reduce overall use, risk and dependence on pesticides, and increase support for community-based control over a sustainably produced food supply. PAN is committed, in its projects, strategies and campaigns to place pesticide concerns in the broad political and economic context in ways that will advance the fight against rural poverty and enhance pro-poor development and ethical trade. PAN aims to help local communities use the initiatives to benefit their day-to-day lives.

PAN Germany is part of the international Pesticide Action Network. It is supporting non-chemical pest management on tropical crops that are commonly grown by small landholder farmers through the project: Online Information Service for Non-chemical Pest Management in the Tropics, OISAT (www.oisat.org).

OISAT is a web-based system to distribute information on non-chemical pest management that is easy to read and easy to understand. Information provided via www.oisat.org is relevant to small-scale farmers who intend to produce crops using safer and more affordable non-chemical pest management practices. It provides varied information on how to lower the cost of production based on recommended insect/mites pests, disease, and weeds control methods.

This ‘Field Guide to Non-chemical Pests Management in Tomato Production’, is an excerpt taken from the website, www.oisat.org. It enables to provide farmers with practical guides and alternatives to eliminate the use and their dependence on synthetic pesticides for the management of tomato pests. The recommended practices are safer, more affordable, and easy to follow. Most of the farm practices, the farmers can do by themselves and the materials that are needed are found in their backyards or in their kitchens or can be purchased in the local agricultural suppliers.

Carina Weber
(Executive Director PAN Germany)

How to use this field guide

This field guide is designed to make the control of tomato pests as easy as possible. Each pest included has a brief description of its lifecycle, damage it causes, and the control measures. It is very important to know how the insect/mite pest develops because the adult does not always cause the damage and sometimes it is not even found where the damage occurred. Also, as not to confuse you with the beneficial ones, a separate description of the natural enemies and their conservation and management are discussed at the last part. Included in the control measures are cultural practices, physical control, plant extracts, other homemade solutions, and other practical methods.

For example, you notice that the tomato leaves are having white spots when you're out in the field. What would you do? First, have a closer and careful examination of your plant. If you find the pest and can't identify it, turn the following pages and look at the illustration of an insect and/or the damage or symptom in each pest entry. Once you have identified the pest, look into the corresponding control measures on how to lessen its population density. You have various options like: cultural practices (e.g. removal of weeds); physical control (e.g. handpicking); plant extract (e.g. neem spray); other homemade solution (e.g. soap spray); other method (use of baits).

However, with every effort made to provide you with complete information on the natural pest control on tomato, the recommendations may vary from every location. It is highly recommended that you have to try the various control practices in small scale especially for the plant extracts and other homemade solutions, in order to make adjustments that are adaptable to your local farm conditions before going into large scale application. And best of all, always keep farm records to have a list of successes and failures in each time you grow a crop!

General recommendations

Throughout this field guide you will find suggestions for lessening the pests' population before they have control over your tomato field. To make a plan for you to grow a healthy crop, the following tips are the steps you ought to take:

1. Learn to identify the pests and other causal agents and the natural enemies
2. Select the proper tomato variety that is well adapted to your local conditions
3. Always select good and diseased-free seeds and transplant only pest-free seedlings. If possible, treat seeds to kill seed borne pathogens and insect pests
4. Have a healthy soil, and always keep in mind that over-fertilizing isn't necessarily better
5. Practice crop rotation by planting on the next cropping season- crops of different family group
6. If possible practice intercropping to improve the field's diversity and to encourage natural enemies
7. Follow the recommended planting distances and practice staking
8. Prepare the soil thoroughly by appropriate tillage
9. Always practice proper field sanitation by removing and pruning infested plant parts, keeping the area free of weeds and other plant residues, and cleaning regularly all farm tools and implements
10. Monitor your plants regularly
11. When in doubt, always ask for assistance from your local agriculturists

When controlling pests using the plant extracts and other homemade solutions, the following are the standard procedures for their preparation and application;

1. Select plants/plant parts that are pests-free.
2. When storing the plants/plant parts for future usage, make sure that they are properly dried and are stored in an airy container (never use plastic container), away from direct sunlight and moisture. Make sure that they are free from molds before using them.
3. Use utensils for the extract preparation that are not used for your food preparation and for drinking and cooking water containers. Clean properly all the utensils every time after using them.
4. Do not have a direct contact with the crude extract while in the process of the preparation and during the application.
5. Make sure that you place the plant extract out of reach of children and house pets while leaving it overnight.
6. Always test the plant extract formulation on a few infested plants first before going into large scale spraying.
7. Wear protective clothing while applying the extract.
8. Wash your hands after handling the plant extract.

Insects/Mites

Ants



Damage

Ants take the sown seeds back to their colony, feed on germinating seeds and on young seedlings. They tend insect pests like aphids, scales, whiteflies, mealybugs, and other honeydew producing insects. These actions result in missing hills, thus loss of plant stand, uneven growth distribution in the field, and an increased incidence of diseases caused by the abovementioned insects.

Description

Eggs are delicate, soft, white, and are laid in clusters of 75-125 eggs.

The larva is grub-liked, legless, very soft, and whitish in color. It inflicts no damage as it depends on the worker ant (older sibling) for care and food. The pupa is whitish and develops inside the ant's nest. It has visible legs and in some cases, wings. The pupal stage is the transitional stage between the larva and the adult which emerges during the final molt.

An adult ant varies in color, from blackish to reddish-brown depending on its species. It has robust mandibles with strong teeth that could inflict painful bites. It has elbowed- antennae, a thin waist, and if it is winged, the hind wings are smaller than the front wings and have few veins.

Ants are also beneficial insects because they prey on termites, eggs, pupa, and caterpillars of other insect pests. Nevertheless, ants should not be introduced into vegetable gardens for insect pest control.

Control measures

Cultural practices

Increase the seeding/seedling rate. This practice turns out cheaper than with the use of insecticide.

Control mealybug, aphid, whitefly, and other insects that excrete honeydew. The ants are likely to be found in plants infested by these insects because they protect them for their food.

Other solutions

Ant oil spray

Mix 2 tbsp dish washing soap, 2 tsp vegetable oil, 2 tbsp salt, and few drops of vinegar into 4 liters of water.

Soap spray

Soap spray

Method of preparation

Mix 2½ tbsp of liquid soap to a gallon of water.
Stir well.

Another method is to mix 1 tbsp of dish-washing detergent with 1 cup of cooking oil, to make a stock solution. For a gallon of spray, add 5-8 tbsp of stock solution to a gallon of water.

Pests controlled

Ants
Leafhoppers
Mealybugs
Psyllids
Scales
Spider mites
Thrips
Whiteflies and
Plant diseases

Aphids



Damage

Both the nymphs and the adults pierce the plant tissues to feed on plant sap. The infected leaves become severely distorted when the saliva of aphids are injected into them. Heavily infested ones will turn yellow and eventually wilt because of excessive sap removal. The aphids' feeding on the plant causes crinkling and cupping of leaves, defoliation, and stunted growth.

Aphids produce large amounts of a sugary liquid waste called honeydew. A fungus, called sooty mold, grows on honeydew deposits that accumulate on leaves and branches, turning leaves and branches black. The appearance of a sooty mold on plants is an indication of an aphid infestation.

Description

The eggs are very tiny, shiny black, and are found in the crevices of bud, stems, and barks of the plant.

The nymphs look like the young adults, mature within 7-10 days, and are then ready to reproduce.

The adults are small, 3-4 mm long, soft-bodied insects with two projections on the rear end and two long antennae. Their body color varies from yellow, green, brown, to purple. Females can give birth to live nymphs as well as can lay eggs. However, the primary means of reproduction for most aphid species is asexual, with eggs hatching inside their bodies, and then giving birth to living young. Winged adults, black in color, are produced only when it is necessary for the colony to migrate, or there is either overcrowding in colonies, or unfavorable climatic conditions.

Control measures

Cultural practices

1. Control and kill ants. Cultivate and flood the field. This will destroy ant colonies and expose eggs and larvae to predators and sunlight. Ants use the aphids to gain access to nutrients from the plants.
2. Avoid using heavy doses of highly soluble nitrogen fertilizers. Aphids love tender, juicy leaves. Instead apply fertilizer into 3 phases: during seedling, vegetative, and reproductive stages of plant growth.

Physical control

Yellow basin trap

Half-fill yellow pan or basin with soapy water. Place the pan close to the plant but exposed enough so that aphids will see it.

Yellow sticky board traps (refer to p. 19)

Plant extracts

Ginger rhizome extract

Grind 50 g of ginger and make into paste. Mix with 3 liters of water. Strain. Add 12 ml of soap. Mix well. Ten (10) kg of ginger in needed for 1 ha.

This spray also controls plant hoppers and thrips.

Custard apple leaf extract

Boil 500 g of leaves in 2 liters of water until the remaining liquid is about ½ liter. Strain. Dilute filtrate with 10 -15 liters of water. This spray material also controls other caterpillars.

Neem leaf extract (refer to p. 13)

Neem seed extract (refer to p. 13)

Other solutions

Ammonia spray

Mix 1 part ammonia with 7 parts water. This spray also controls flea beetles, scales, thrips, and whiteflies.

Flour spray (refer to p. 21)

Soap spray (refer to p. 10)

Cutworm

Damage



Cutworms feed on seedlings. The seedlings are often cut off at ground level. The larvae can be found in the soil (up to a depth of about 5 cm) near the plant. They always curl-up when disturbed. Cutworms feed only at night. Generally, they are not found on plants or on the soil surface during the day. The newly hatched larvae feed from the base towards the tip of the leaf. At this stage, they first feed on the epidermis and may discolor the entire leaf surface. Young caterpillars eat the soft leaves of the plant. The full grown caterpillars are capable of eating the entire plant.

Description

The eggs are tiny pearl white, round, and have a ridged surface.

The newly hatched larvae are greenish and about 1 mm long. The full-grown larva has a cylindrical body, brown or brownish-black with a tinge of orange. The thoracic segments have one to two dark spots near the base of the legs. The abdominal segments generally have two light brownish lateral lines on each side, one above and one below the spiracles. Above the top lines are broken lines composed of velvet semi-crescent patches that vary in color among cutworms.

The pupa is black or brown in color and measures about 22.5 mm long and 9.2 mm wide.

The adult has dark brown forewings with distinctive black spots and white and yellow wavy stripes. The hind wings are whitish with grayish margins. The total developmental period from egg to adult is about 35-40 days.

Control measures

Cultural practices

Interplant tomato with onion, garlic, peppermint, coriander, or garlic every 10-20 rows to repel cutworms and attract natural enemies. Sunflowers and cosmos can also be planted as a trap crop in or around fields.

Physical control

Protective collars

Protective collars made of plastic or paper cups, plastic drink bottles with ripped-out bottom, sturdy cardboard, and milk cartons. Place the collar around the young plant and push into the soil to prevent the cutworm from attacking the stem.

Sticky substances

Molasses, saw dusts, or crushed eggshells placed around the base of each plant as traps. When cutworm emerges to feed, it will come in contact with the trap, get stuck, harden, and die.

Plant extracts

Finger euphorbia plant extract

Cut a branch and collect the oozing sap. Add 1 liter of water to every 10 drops of the sap. Another method is to cut a mature branch and pound it finely to make it into a paste. Add this to 10 liters of water. Leave it for sometime then strain.

Basil plant extract

Pound or grind of 50 g of basil leaves. Soak it overnight in 2-3 liters of water. Add 8 - 12 ml of soap. Stir well.

Other method

Bacillus thuringiensis (BT)/bran bait

Moisten bran with a diluted solution of BT. Sprinkle the moist bran on the planting plots' surfaces 2 weeks before planting. Buy BT at your local agricultural suppliers.

Flea beetles

Damage

Flea beetles feed on seedlings. They usually feed on the undersides of leaves leaving numerous small round or irregularly shaped holes, although not generally all the way through the leaf. Because the beetle is small and active, it usually does not feed much in one spot.

The larvae are root feeders. They trim the root hairs and make circular pits in taproots. The adults feed on the leaves and stems of emerging seedlings. They chew small holes or pits, usually less than 3 mm in diameter giving the leaves a characteristic 'shot hole' appearance.



Description

The eggs are tiny white when freshly laid and gradually become yellowish-gray in color.

The larva is white with a brown head and three pairs of brown legs near its head.

The pupa is white, shaped roughly like adult and pupates in the soil. It is found in the soil near the base of the plant on which it has been previously feeding.

The adult is small, hard, elongated, oval-shaped, with enlarged black hind legs and slightly hairy wing covers. It is about 2 mm in size. It is bronze, dark-metallic bronze or black in color. It has enlarged hind legs. They all jump vigorously like fleas when disturbed, hence the name.

Control measures

Cultural practices

Rotate tomato with wheat or sunflowers or with other observed non-host crops.

Physical control

Row covers

Keep flea beetles away by putting row cover on seed boxes and/or seed beds immediately after sowing.

White or yellow sticky traps

Mulching

Place 2-3 inches of cut grasses or 2-4 inches of bark mulch and wood chips or 3-4 inches of compost as your mulching materials to interfere the larvae's root feeding activities.

Plant extracts

Neem oil extract

Neem seed extract

Add 30 grams of powdered kernel in 1 liter of water. Let it stand for 6 hours but not more than 16 hours. Add soap and stir. Constantly shake the container or stir the extract while in the process of application.

Neem oil extract	Neem leaf extract
Method of preparation Add 30 ml of neem oil into 1 liter of soapy water. Constantly shake the container or stir the extract while in the process of application to prevent oil from separating. **Pests controlled** Flea beetles Gall midge Leafhoppers	**Method of preparation** Pound gently 1-2 kg of neem leaves. Place in a pot. Add 2-4 liters of water. Cover the mouth of the pot securely with the cloth and leave it as such for 3 days. Strain to get clear extract. Dilute 1 liter of neem leaf extract with 9 liters of water. Add 100 ml of soap. Stir well. **Pests controlled** Aphids Colorado potato beetles Grasshoppers Grubs Japanese beetles Leafhoppers Locusts Plant hoppers Scales Snails Thrips Weevils Whiteflies

Hornworm



Damage

The larvae eat the leaves, initially attacking the upper portion of plants and thereby consuming foliage, blossoms, and green fruits. They usually consume the entire leaf and are capable of high levels of defoliation. The highest foliage consumption occurs during the final stage because of its large size. They blend in with the foliage and are not easy detected.

Description

The eggs are spherical to oval in shape and measure about 1.50 mm in diameter. The color varies from light green to white. Eggs are deposited both on the lower and the upper surfaces of foliage.

The larva is cylindrical and bears five pairs of prolegs in addition to the three pairs of thoracic legs. It has a thick pointed structure or horn located dorsally on the terminal abdominal segment. The horn is dark-green with black sides. It has a V-series of white striping along the sides of its body.

The pupa is large and elongate-oval, but pointed at the posterior end. It measures 45-60 mm in length. The pupa bears a pronounced maxillary loop, a structure in the upper jaw which encases the mouthparts.

Adults are large moths with stout, narrow wings. A moth has a wingspan of about 1 cm. The forewings are much longer than the hind wings which are dull-grayish or brown in color. The sides of the abdomen are usually marked five spots. The hind wings bear alternating light and dark bands. Adults are known as sphinx and hummingbird moths.

Control measures

Cultural practices

Plant dill as trap crop and basil and marigold as repellents.

Physical methods

1. Handpick the larvae and feed them to chicken or kill them by drowning in soapy water. They are easy to pick due to their large size but you must be very observant because they easily blend with the color of the plant's leaves.
2. Use light traps (kerosene lamps or petromax) to attract adults. Place the kerosene lamps near the shallow discs of water to drown the moths.

Leafhoppers

Damage

Both the nymphs and the adults' leafhoppers feed on the plant sap. They then suck out the liquid contents leaving behind the dead and empty cells which are small, white spots. Heavy feeding results to 'hopperburn' which is caused by the toxic effects of the insects' saliva. It also causes mosaic virus disease as the pests are carriers of the virus.

Description

The eggs are laid inside the soft plant tissue on the underside of the leaves. They are elongate or curve, whitish to greenish, and about 0.9 mm long. Eggs hatch in about 10 days.

The nymphs look similar to the adults but are very small, pale yellow-green, and wingless. They undergo five nymphal stages. Their cast skins usually remain on the lower surface of the leaf. Nymphs have the ability to walk sideways, forward or backward at rapid paces.

Adults are small, elongate, wedge-shaped insects about 3-4 mm long. They hop fast, fly quickly, and can run in all directions when disturbed, hence the name leafhopper. Many leafhoppers look alike and their colors vary; from green, gray, tan, brown, banded, which often lead to misidentification of the different species.



Control measures

Physical control

Row cover

Use row covers to prevent the seedlings from the early attack of the pest

Plant extracts

Garlic oil extract

Neem oil extract (refer to p. 13)

Garlic oil extract

Method of preparation

Chop finely 100 g of garlic. Soak the chopped garlic in mineral oil for a day. Add ½ liter and 10 ml of soap. Dilute filtrate with 10 liters of water. Constantly shake the container or stir the extract while in the process of the application to prevent oil from separating.

Pests controlled

Leafhoppers
Imported cabbage worm
Squash bugs
Whiteflies

Leafminers

Damage

The larvae make long, slender, winding, white tunnels in leaves. Severely mined leaves may turn yellow, disfigured, and drop. Severely mined seedlings are stunted and eventual death occurs.

Description

The eggs are laid under the surface of leaf epidermis, are ovate, creamy-white in color, and tiny- about 0.10-0.15 mm in diameter. The eggs hatch after 2-5 days.

The larva is legless, whitish to yellow green with a darker head. It has a mouth hook structure that is retractable into the body. A newly hatched larva tunnels through the mid-leaf tissues leaving its characteristic wavy lines that are visible on top of the leaf. It undergoes 3 larval stages that last for 4-7 days. When the larva is ready to pupate, it cuts a hole where it stays and feeds and usually drops to the soil to pupate.

The pupa varies in color, from yellowish-brown to almost black, and distinctly segmented. It is oval-shaped, becoming narrow at the end. The pupal stage lasts for 10-12 days.

Adult is a small fly, about 2.5 mm long. It is grayish to black with yellow markings. Female flies are slightly larger than males.



Control measures

Cultural practices

Conservation of the natural enemies is an important aspect of leafminer management. Maintain flowering grasses around field margins to provide habitat and food for natural enemies.

Physical methods

Kitchen funnel

Inverted kitchen funnel capped with a plastic vial to monitor adults' emergence from the seedbeds.

Plastic trays

Place the trays under the plants to monitor and catch pupating larvae as they leave the plants to pupate in the soil.

Yellow plastic gallon containers

Mount containers upside down on sticks coated with transparent automobile grease or used motor oil. These should be placed in and around the field at about 10 cm above the foliage. Clean and re-oil when traps are covered with flies.

Yellow plastic drinking cups

Coat cups with adhesive (used motor oil) and stapled on stakes above plant canopies to trap flies.

Yellow plastic trapping sheets

A 2 m long x 75 cm wide yellow plastic sheet coated with motor oil, both ends attached to bamboo or wooden poles and carried by 2 persons through the field to mass capture adult flies.

Plant extracts

Ginger, garlic, and chilli extract

Neem powdered seed extract (refer to p. 17)

Ginger, garlic, and chilli extract

Method of preparation

Soak 50 g of peeled garlic overnight in 10 ml mineral oil.
Combine garlic, 25 g of green chilies, and 25 g of ginger.
Add 50 ml of water to the mixture. Grind them.
Add 3 liters of water.

Pests controlled

Aphids
Armyworm
Cotton bollworm
Caterpillars
Corn earworm
Fruit borers
Leafminers
Shoot borers
Thrips
Tomato fruitworm
Whiteflies

Psyllids

Damage

Nymphs and adults suck plant juices causing retarded growth of the internodes, upward cupping or rolling of leaves, and thickening of leaves. Leaf margins and other plant parts can become yellow, reddish or purplish. Older leaves and heavily injured plants may die. Psyllid-yellows and Purple-top are the common symptoms as results of toxic saliva injected by the insects.

Tomatoes that are attacked during the vegetative stage may bear no fruits. A later attack can cause the production of an abnormal number of fruits that will never attain the desired fruit sizes.



Description

Eggs are very small, ovate-shaped, and yellow to orange in color. Egg is found singly on very fine stalks usually along leaf margins. Eggs are not visible to naked eyes.

Nymphs are flattened and somewhat scale-like with a fringe of short spines around the edge. Newly hatched nymphs are yellowish and turn pale-brown to green as they mature. They undergo four nymphal stages and are usually found on lower leaves and on lower leaf surfaces.

Adults are striped with alternating dark and light bands. Their common name (Jumping plant lice) is derived from their ability to jump backwards when disturbed. A mature female can lay over 500 eggs. Their lifecycle is 15-30 days.

Control measures

Cultural practices

Select tomato varieties that have extra hairy leaves for they are less attractive to psyllids.

Physical methods

Yellow sticky board traps (refer to p. 19)

Plant extracts

Neem oil extract

Add 15 ml of neem oil into 1 liter of soapy water. Constantly shake the container or stir the extract while in the process of application to prevent oil from separating.

Neem powdered seed extract

Method of preparation

Add 50 grams of powdered kernel in 1 liter of water.
Let it stand for 6 hours but not more than 16 hours.
Add soap and stir.
Constantly shake the container or stir the extract while on the process of application.

Pests controlled

Aphids
American bollworms
Cotton leaf rollers
Diamondback moths
Grasshoppers
Leafhoppers
Leafminers
Red locusts
Mexican bean beetles
Whiteflies

Spider mites



Damage

Generally, mites feed on the undersides of leaves. They use their sucking mouthparts to remove plant saps. The upper leaf surface has a speckled or mottled appearance while the underneath appears tan or yellow and has a crusty texture. Infested leaves may turn yellow, dry up, and drop in a few weeks. Mites produce large amount of webbing. Heavy infestation will result in a fine cobwebby appearance on the leaves. Plants die when infestation is severe.

Description

The eggs are tiny, spherical, pale-white, and are laid on the undersides of leaves often under the webbings. Eggs hatch in 4 or 5 days.

Nymph looks similar to the adult but is only the size of an egg. It has only 6 legs. It molts 3 times before becoming an adult.

The adult is also very tiny, maybe yellowish, greenish, pinkish, or reddish depending on the species. It looks like a tiny moving dot. It has an oval body with 8 legs and with 2 red eyespots near the head of the body. The male is smaller than the female with a more pointed abdomen. A female usually has a large, dark blotch on each side with numerous bristles covering her legs and body. Spider mite is not an insect.

Control measures

Cultural practices

1. Provide plants with adequate water. Water-stressed plants are prone to damage by mites.
2. Avoid the use of broad spectrum insecticide for this may cause a mites' outbreak. This practice kills the natural enemies of mites and stimulates mites' reproduction.

Physical control

1. Hosing with a strong jet of water knocks off mites and destroys their webs. Be sure to include the underneath of the leaves.
2. Apply water to pathways and other dusty areas at regular intervals.

Plant extracts

Coriander seed extract

Pound or crush 200 grams of coriander seeds. Boil in 1 liter of water for 10 minutes. Cool and strain. Dilute extract with 2 liters of water. This extract also prevents fungal diseases.

Other solutions

Horticultural oil

Spray 2% solution against mites. To make a 2% solution, pour 1/3 cup oil into a 1 gallon container, and then fill with water to make a 1 gallon solution. For a 3% solution, start with ½ cup of oil. Apply successive sprays at least 6 weeks apart. You can apply 1% oil solution by mixing 2.5 tbsp of oil in 1 gallon of water. Horticultural oil is concentrated and must be mixed with water.

Other method

Basil leaf extract

(refer to p. 25)

Milk spray

Milk spray

Method of preparation

Mix ½ liter of milk to 4.5 liters of water (Milk and water ratio is 1 part milk to 9 parts water). Spray at weekly interval as a preventive control measure.

Pests controlled

Spider mites
Mildews
Mosaic virus
Leaf blights
Fungal diseases

Thrips



Damage

Thrips have rasping-sucking mouthparts and feed by rasping the surface of the rapidly growing tissues of the leaves and sucking up the released plant fluid. Thrips cause tiny scars on leaves and fruit, called stippling, which can cause stunted growth. Damaged leaves may become papery and distorted. Infested terminals lose their color, rolled, and drop leaves prematurely.

Description

The egg is very tiny and is impossible to see. A single egg is 0.25 mm long and 0.1 mm wide. It is white when freshly laid and turns pale yellow toward maturation.

The nymph is elongated, elliptical, slender, and is pale yellow in color. It is very small from 0.5-1.2 mm in size. Its eyes have darker coloration and are easy to see. Immature thrips do not have wings.

The pupa appears as an intermediate form between the nymph and the adult. It has short wing buds that are not functional. At this stage, they do not do any damage to the plant.

The adult has a slender small body, yellowish to dark brown in color, and is cigar-shaped. It is 1-2 mm long with a well-pronounced 5-8 segmented antennae. It can exist in two forms, winged or wingless. The winged form has two pairs of elongated narrow wings which are fringed with long hairs. Female thrips can reproduce both sexually and asexually.

Control measures

Cultural practices

1. Tomato should not be planted after onions. Volunteer onion plants should be removed as they attract thrips. However, they can be used as trap crops.
2. Keep plants well-watered. Lack of water increases the susceptibility of plants to thrips damage.

Physical control

Bright blue or royal blue sticky board traps

Plant extracts

Garlic bulb spray

Finely chop 85 g of garlic. Soak chopped garlic in 50 ml of mineral oil for 1 day. Add 10 ml of soap to the soaked garlic. Dilute with water to make a liter of spray material. Stir well. This spray also controls tomato fruitworm and bacterial and fungal diseases.

Sticky board trap

To use, place 1-4 sticky cards per 300 sq m field area. Replace traps at least once a week. To make your own sticky trap, spread petroleum jelly or used motor oil on painted plywood of desired color, 6 cm x 15 cm in size or up. Place traps near the plants but faraway enough to prevent the leaves from sticking to the board. Traps when hung should be positioned 61 cm zone above the plants.

Pests monitored/controlled

Blue sticky cards
Thrips

White sticky cards
Flea beetles, tarnished plant bugs

Yellow sticky cards
Aphids, cabbage root maggots, carrot rust flies, cabbage white butterflies, gnats, whiteflies

Tomato fruitworm

Damage

The larval feeding damage during the vegetative growth is usually on the tips of the leaves in the developing bud. The leaves become distorted. However, it prefers to feed on the green fruit. It enters through its bored hole at the fruit's pedicel. Its feeding damage is a watery cavity that contains frass (waste matters), causing the fruit to decay or to ripe prematurely.

Description

The eggs are pinhead-size and yellow-green in color. These are found singly laid near the midrib usually underneath the leaf. Hatching occurs within about 2-5 days.

The larvae vary in color from bright green, pink, brown, to black, with lighter undersides. Alternating light and dark bands run lengthwise along their bodies, the heads are yellow and the legs are almost black. Mature larvae vary in length about 3-5 cm. They drop to the ground to burrow into the soil to pupate. The larval stage lasts from 12-24 days.

Pupae are yellowish green and turn brown as they mature. Pupation takes place under the soil. Pupal period is 12-24 days.



An adult male is yellow-brown while a female is orange-brown in color. It has a wingspread size of about 3.8cm. Each female may deposit 200-2,000 eggs in her entire lifetime. Total development period from egg to adult is 34-45 days.

Control measures

Cultural practices

1. Do not plant other solanaceous crops after harvesting tomato. Never use tomato as rotation crop for corn, sorghum, cotton, and other solanaceous crops and vice versa.
2. Avoid planting tomato near corn or cotton or other solanaceous crops to prevent heavy pest infestations.

Plant extracts

Ginger, garlic, and chilli extract

Soak 50 g of peeled garlic overnight in 10 ml kerosene. Combine garlic, 25 g of green chilies, and 25 g of ginger. Add 50 ml of water to the mixture. Grind them.

Add 3 liters of water.

Physical methods

Pheromone traps

Place pheromone traps at a distance of 3 meters. If use to monitor the pest, place 2-3 traps in a hectare field area. Buy the pheromone that attracts the pests you want to control. Read the label and follow the instructions properly.

To make your own traps, make 10-12 holes into an old plastic bottle or 3 holes on each side of a used 1 liter ice cream container to allow moths to enter. Place a wire to suspend the bait. Half-fill the container with soapy water. Hang the pheromone capsule using a string or wire. Attach the trap to a stake or hang it on branch of a tree.

Handpicking

Handpick damaged fruits and collect those that fall down. Destroy the damaged fruits by cutting into small pieces or place them in sealed sacks and dry under the sun. Putting them immediately in compost pit or burying them will enable the matured larvae to pupate into the soil.

Whiteflies

Damage



Both the larvae and adults pierce and suck the sap of the leaves. This causes the weakening and early wilting of the plant resulting in reduced plant growth. Their feeding may also cause yellowing, drying, premature dropping of leaves that result in plant death.

Whiteflies produce honeydews that serve as the substrates for the growth of black sooty molds on leaves and fruit. The mold reduces photosynthesis causing the poor plant growth of the plant. They are the most important carriers of plant viruses that cause diseases of fiber crops, vegetables, fruit trees, and ornamentals.

Description

The eggs are tiny, oval-shaped, about 0.25 mm in diameter, and stand vertically on the leaf surface. Newly laid eggs are white then turn brownish. They are deposited on the underside of leaves, sometimes in a circle or oval-shaped patterns.

The larvae are transparent, ovate, and about 0.3-0.7 mm in size and they move around on the plants looking for a feeding site upon hatching.

The pupae are dirty-white and surrounded by wax and honeydews. During this stage, the red eyes of the emerging adults are visible.

The adults are about 1mm long with two pairs of white wings and light yellow bodies. Their bodies are covered with waxy powdery materials. They are found feeding on top of the plants. A female can produce as many as 200 eggs in her lifetime and mating is not necessary. It takes about 40 days to develop from egg to adult.

Control measures

Cultural practices

1. Do not plant tomato near crops that have whitefly infestation. This would lead to early infestation of your crop and could ruin the whole field crop.
2. Plant Nicotania as a trap crop. Whiteflies are attracted to Nicotiana, a flowering tobacco plant variety.

Plant extracts

Madre de cacao & neem extract

Shred 1 kg of Madre de cacao leaves and 1 kg of neem leaves. Soak leaves in 5 liters of water for 3 days. Strain. Add water to make up 20 liters of filtrate. Spraying interval is 4-5 days.

This spray also controls aphids, armyworm, termites, and white grubs.

Neem oil extract

Add 15 ml of neem oil into 1 liter of soapy water. Constantly shake the container or stir the extract while in the process of application to prevent oil from separating.

Other methods

Ammonia spray
(refer to p. 11)
Flour spray
Soap spray
(refer to p. 10)

Flour spray

Method of preparation

Add 2-4 tbsp of wheat or potato or any baking flour into 4 cups of warm water. Add 1 tsp of soap as sticker. Stir the filtrate prior to application.

Pests controlled

Aphids
Spider mites
Thrips
Whiteflies

Wireworm

Damage

Wireworms destroy the germinating seeds and tiny seedlings by cutting off underground roots resulting in missing stands. They attack the stems of newly set plant by boring into the stems near the soil surface. Some plants may wilt and die within a few days or may have stunted growth. Often, the wireworm is found near the damaged or missing seed or plant.



Description

Wireworms are the larvae of different species of Click beetles. Larvae are slender and hard and feel somewhat like wires. Their bodies are segmented and shiny and are usually cylindrical, but flat on the lower sides. There are three pairs of legs close together near the head and no prolegs. Some of the most common species are white, yellowish-brown to reddish-brown, although other species may vary in color.

Control measures

Cultural practices

3. Where damage has been severe in the previous cropping seasons, avoid planting or fallow the area. Click beetles, the adult wireworms, return to the same fields to lay eggs.
4. If field is irrigated, flood it for at least a month, during sunny weather, to eliminate wireworms.
5. Grow Flax (Linum species) as a cover crop to kill wireworms. It is also good for controlling root knot nematodes. White mustard and Buckwheat plants are also found to reduce the wireworm population.

Physical control

Corn/wheat seed mixture bait

Soak mixture in water for 24 hours to facilitate germination. Place ½ cup (of a 1:1 corn/wheat seed mixture) in a hole that is 12 cm wide and 30 cm deep. Cover with soil. Cover the topsoil with plastic to warm the surface and to speed up germination. Cover the edges with soil to prevent wind from blowing away the plastic. Remove the plastic, the soil cover, and the bait. Destroy larvae trapped in the baits. This method is also used to monitor white grub population.

Potato/carrot bait

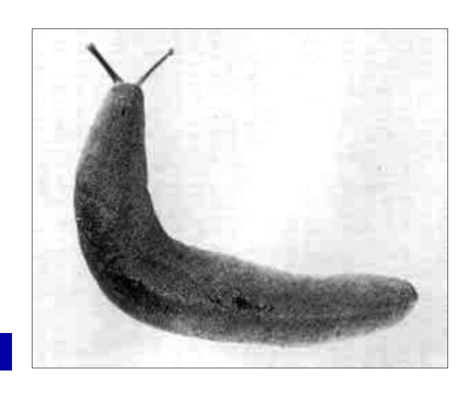
Cut potatoes or carrots into chunks. Remove the potato 'eyes' to prevent from further growing. Make the pieces big enough and put in sticks. Bury "staked potatoes/carrots" at a depth of 3-6 cm in the ground. The stick serves as the handle to easily pull the baits out. Bury randomly in the field. Leave baits in the soil for 2-3 days. Wireworm will feed on the baits. Dispose the baits and the wireworm properly.

Plant extract

Red cedar leaf extract for seed treatment

Pound 1 kg of red cedar leaves. Soak the pounded leaves in equal amount of water overnight. Strain to get a clear filtrate. Treated seeds should be sown immediately.

Slugs and snails



Slugs

Damage

Slugs feed on the seedlings, soft plant parts, and the ripening fruits near the soil. Their feeding damage on the leaves is irregular large holes but they can consume the young seedlings completely.

Description

The eggs are about 4 mm in diameter, colorless, gelatinous and watery, and are laid in cluster of 10-50 eggs beneath the soil surface. They hatch after 10 days but it can be up to 100 days in cooler temperatures.

The hatchlings are very small, transparent, and resemble the adult counterparts. They mature in less than a year.

The mature slug does not have a hard protective spiral shell but has a little hard shell enclosed in its mantle. A slug protects its entire body with a sticky slime. Its size ranges from 1.2-25 cm and its appearance and habit vary depending on the species. Its color also varies from ash-gray, light brown, yellowish-gray, brownish-orange, to black.

Some species have the same color in their entire bodies but others have streaks. Slugs die in high temperatures or during winter, but under normal conditions they can live up to 6 years. Their lifecycle continues because the eggs can withstand both the extreme temperatures. They have thick outer shells made of calcium carbonate.

Control measures

Cultural practices

Limit the addition of organic matters into the area when the infestation is causing economic loss because organic matters are very attractive to slugs. Slugs eat on organic matters found in the soil.

Physical control

1. Screen the seedbed or seedling plot using a fine mesh screen of about 7.5 cm high that surrounds the plot and securely fix about 2.5 cm of it into the ground.
2. Trap the slugs using 30 cm x 30 cm white painted-surface wooden boards. Place them securely along the plant's rows. At daytime, slugs take shelter underneath the cooler places. Be sure to check the wooden traps before sunset and collect the slugs. Crush or place them in a bucket of soapy water. Potato or cabbage, cereal bran or chicken food can be placed under the board as an attractant.
3. Over-turned earthen flower pots, placed under the shady part of the plant, is another way of trapping them. Make sure to make an opening to let them crawl underneath and to collect them before sunset. Crushing them in the pots also make the pots more attractive to other slugs.

Other methods

Plant ash, saw dusts, sand, or eggshells

Sprinkle enough ash, sand, or crushed eggshells at the base of the plants. The slugs are sensitive to harsh objects which prevent them from crawling into the plants. Remember to keep these substances dry to be effective. But make sure that your control method is not a waste of time because slugs are problematic only when the soil is moist.

Grapefruit and melon peel baits

After eating grapefruit and/or melon, invert the peel as food and as a cool shelter for the pests. Be sure to collect peels and kill the trapped pests.

Bottle traps

Cut the bottle at its shoulder, just before it starts to taper toward the neck. Stick the piece you have just cut off into the bottle, neck first. Tape the two pieces together with electrical tape. Fill the trap half-full with a yeast-water-solution, bury it sideways in your garden so that the entrance is level with the ground. When the trap is full, open the top and empty its contents into the garbage or compost. Make sure that the slugs and snails are killed before disposing of them.

The abovementioned control methods are also recommended for the control of snails.

Common garden snail



Damage

Snails feed on seedlings, soft plant parts, ripening fruit that are close to the soil, and organic matter. Their feeding damage is irregular large holes on leaves but they can consume the young seedlings completely.

Description

The eggs are white and spherical, about 3 mm in diameter in size. These are deposited in a cluster (an average of 86 eggs) in a nest found 2.5-4 cm deep below the soil surface. The egg mass is concealed by a mixture of soil with secreted mucus followed by a quantity of excrement. The eggs will hatch in about 2 xxx.

The hatchling is fragile and translucent. It will reach maturity in about 10 months and/or 2 years depending upon the environmental conditions.

The adult common garden snail has a large and spherical thin shell that is moderately glossy and sculptured with fine wrinkles. It is yellow or horned-colored with chestnut brown spiral bands, adorned with yellow streaks. An adult can measure up to 3-3.4 cm in diameter.

Snails are hermaphrodites, having both the male and the female reproductive organs. They have to mate to reproduce but cases of self-fertilization are reported to occur. Snails are nocturnal and come out to feed at night time. They are very active when the soil is wet. When the temperature is unfavorable, they can hibernate for months in the soil and become active again when the rainy season comes.

Control measures

Plant extracts

Neem leaf extract (refer to p. 13)

Other solutions

Yeast and water solution

Dissolve 1 tbsp of yeast in 100 ml of water. Fill any shallow container with the solution. Bury up to the rim near the plant. Make some modifications to cover your trap to avoid non-target pests from entering. The snails drink, get drunk and drown in the pan. Monitor the pans and the trapped snails. Change the solution when necessary, especially after rain.

A 2% caffeine solution in water

Spray directly on the trapped pests. Test solution on a few plants first as it can cause yellowing to some leaves.

Nematodes

Root knot nematodes

Host

A wide variety of agricultural crops and weeds

Symptoms

Infected plants have swollen, impaired roots. Nematode's feeding stimulates the production of galls (root knots). Galls are found on the root system both on the primary and secondary roots. Their sizes vary from .02 to 20 cm in diameter.

The gall is characterized by smaller swellings and more uniformly distributed infection on the lateral feeding roots. Inside the gall are shiny white bodies of the female nematodes (about the size of a pinhead). At the root surface, shiny white to yellow egg masses are found. A closer look with a magnifier may show the adults, but mostly they are not seen with the naked eye.

Severe infestation results in stunted growth, yellowing of leaves, wilting, and poor yield because the galls disturb the roots ability to absorb water and nutrients. They also serve as openings for pathogens, such as fungi and bacteria, which cause plant diseases.

Prevention and control

1. Rotate tomato with broccoli, cauliflower, sorghum, rape, and mustard seed
2. Plowing under African marigold (T. minuta)
3. *Basil leaf extract*
4. *Fermented marigold extract* (refer to p. 29)
5. *Neem powdered seed extract* (refer to p. 17)

Pound gently 3-5 kg of de-shelled neem seeds. Add 10 liters of water. Cover the mouth of the pot securely (with the cloth) and leave it as such for 3 days. Strain to get clear extract. Dilute 1 liter of this extract with 9 liters of water. Add 100 ml of soap. Stir well. This spray material also controls most of the insects/mites pests of tomato.

Basil leaf extract

Method of preparation

Grind leaves 50 g of basil leaves
Soak overnight in 2-3 liters of water
Strain
Add 8-12 ml soap
Stir well

Pests controlled

Caterpillars
Fruit flies
Red spider mites
Red scales
Spotted leaf beetles
Fungal diseases
Nematodes

Diseases

Alternaria leaf spot



Symptoms

Alternaria stem canker (lesion) appears on stems, leaves, and fruit. An infested stem near the soil line has dark-brown to black cankers with concentric rings. When the lesions enlarge, they girdle the stem and eventually kill the plant. Fruits that are harvested from infested plants have brown or black necrotic sunken (submerged) lesions.

Prevention and control

1. *Basil leaf extract* (refer to p. 25)
2. *Onion bulb extract*
3. *Compost tea spray*
4. *Milk spray* (refer to p. 18)

Anthracnose

Symptoms

Infected ripe tomato fruit has small, watersoaked, sunken, circular spots that may increase in size up to 1.2 cm in diameter. As it ages, the center of an older spot becomes blackish and emits gelatinous pink spore masses. The anthracnose lesions easily attract other rotting organisms to completely rot the infected fruit. Infection may also occur on unripe fruits, stems, leaves, and roots. Infected unripe fruits do not show symptoms until ripening. Infected roots, called black dot root rot, only become evident when the fruits begin to ripen. The root lesions become brown and are dotted with fruiting bodies. The outer layer of the infected roots is completely rotten.

Prevention and control

1. *Baking soda* (refer to p. 30)
2. *Basil leaf extract* (refer to p. 25)
3. *Compost tea spray*
4. *Onion bulb extract*

Onion bulb extract

Method of preparation

Finely chop 50 g bulb onion.
Add to 1 liter of rain water. Strain.

Diseases controlled

Alternaria
Anthracnose
Fusarium wilt
Fungal leaf blight

Compost tea spray

Method of preparation

Put a gallon (4 liters) of well-matured compost into a 5 gallon (20 liters) container.
Add water until the container is full.
Stir well.
Place in warm place for 3 days to ferment.
Strain.

Diseases controlled

Fungal diseases

Bacterial leaf blight

Symptoms

Infected tomato leaf has dark watersoaked circular spots which are about 3 mm in sizes but may become larger when the temperature is right. The spots become angular and turn brown-black. Eventually, the centre of the spots may dry and leaf may drop prematurely. Infected young fruit has small black spots. As the bacteria further develop, the spots turn brown, slightly sunken, scabby, and sometimes surrounded by rings. Severe infestation gives the plant the appearance of blight.

Prevention

1. *Compost tea spray* (refer to p. 26)
2. *Copper spray* (refer to p. 29)
3. *Garlic bulb extract* (refer to p. 29)
4. *Lemongrass extract*
5. *Mint extract* (refer to p. 27)

Bacterial wilt

Symptoms

The initial symptom is a wilting of the terminal leaves, which after 2-3 days becomes permanent when the whole plant wilts due to the active development of the disease. Then the whole plants wilt and die suddenly. In the case of a slow development of the disease, the plant stunts and produces large numbers of adventitious roots on the stem.

Bacterial wilt diagnosis in the field can be done easily. Cut a piece of the stem 2-3 cm long from the base. Suspend the cut stem in clear water in a glass container. Hold the stem with an improvised tong to maintain it in a vertical position. Within a few minutes, the smoke-like milky threads are discharged from the cut stem.

Prevention

1. Rotate tomato with rice, corn, beans, cabbage, and sugarcane that are found to be resistant to bacterial wilt.
2. Wash or expose farm tools to heat before using in another field since the bacteria can be transmitted through them.
3. *Mint extract*

Lemongrass extract

Method of preparation

Soak 50 g of ground lemongrass in 2 liters of water for a few hours
Strain

Diseases controlled

Late blight
Bacterial diseases

Mint extract

Method of preparation

Grind 250 g of mint leaves
Make into a paste
Add 2 liters of water
Stir well and ready for use or strain it to have a clear extract

Diseases controlled

Bacterial leaf spots and other bacterial diseases

Downy mildew

Symptoms

Downy mildew infection begins as angular yellow spots on the upper leaf surface. Then they become brilliant-yellow. Eventually, the internal parts of these spots become brown with yellow margins. The underside of this infected leaf has fine, grayish fungal growth. Infected young shoots, fruits, and seeds have white coating of fungal spores.

Prevention and control

1. *Aloe and vitex extract* (refer to p. 29)
2. *Basil leaf extract* (refer to p. 25)
3. *Copper spray* (refer to p. 29)
4. *Compost tea spray* (refer to p. 26)
5. G*arlic bulb extract* (refer to p. 29)
6. *Milk spray* (refer to p. 18)

Early blight



Symptoms

Early blight produces a wide range of symptoms at all growth stages of both potato and tomato which include damping-off, collar rot, stem cankers, leaf blight, and fruit/tuber rot.

Seedlings grown from infested seeds may damp off soon after emergence because large lesions develop at the ground line on stems of transplants or seedlings. Collar rot occurs when the young stem becomes girdled with dark lesions at the soil level.

The infected leaf has circular lesions of about 1.2 cm (1/2 inch) in diameter. Dark, concentric circles (circles with a common center) are found within these lesions. Infection usually begins on the lower, older leaves and progresses up the plant. Infected leaves eventually wilt, die, and fall off. Early blight lesions show a generally dry "bulls-eye" angular pattern that do not usually spread very far and rarely affect petiole tissue, as the progress of the fungus is stopped by the veins of the leaf.

An infected stem has small, dark, slightly sunken areas that enlarge to form circular or elongated spots with lighter-colored centers. Concentric markings, similar to those on leaves, often develop on stem lesions.

Infestation during the flowering stage of tomato causes the blossoms to drop. The fruit stems are spotted with lesions that lead to loss of the young fruits.

An infested tomato fruit has dark, leathery sunken spots, usually at the point of the stem attachment. These spots may enlarge to involve the entire upper portion of the fruit, often showing concentric markings like those on leaves. Affected areas may be covered with velvety black masses of spores. Fruits can also be infected during the green or ripe stage through growth cracks and other wounds. Infected fruits often drop before reaching maturity.

Prevention and control

1. *Basil leaf extract* (refer to p. 25)
2. *Compost tea spray* (refer to p. 26)
3. *Fermented marigold extract* (refer to p. 29)

Fusarium wilt

Symptoms

Infestation often occurs on mature plants after flowering and at the beginning of fruit set. The initial symptom is the yellowing on the lower leaves and a slight wilting on the infected shoots. Yellowing begins to appear on one side of a leaf and then all leaflets become yellow on the other half of the leaf. As the disease progresses one side of the plant wilts. This process spreads to the other side, as the infection worsens. An infected plant often dies before maturing.

Prevention

There is no known effective method to control Fusarium wilt. The following are the preventive measures to cushion the impact of the disease.

Basil leaf extract (refer to p. 25)
Compost tea spray (refer to p. 26)
Onion bulb extract (refer to p. 26)

Fermented marigold extract

Method of preparation

Fill-in container with ½ - ¾ of flowering plants
Leave to stand for 5-10 days.
Stir occasionally
Strain
Dilute filtrate with water at a ratio of 1:2

Diseases controlled

Tomato blights
Rice blast
Coffee berry disease

Garlic bulb spray

Method of preparation

Grind 2 garlic bulbs
Add to 4 cups of water and stir in few drops of soap.
Dilute 1 part of this filtrate with 9 parts of water.

Diseases controlled

Black spots
Blights
Fruit rots
Mildews

Aloe and vitex extract

Method of preparation

Soak 5 kg of vitex leaves in sufficient amount of water and then bring to boil for 30 minutes
Strain
Add 2 liters of aloe vera juice
Stir in 50 ml of soap
Add 50 liters of water

Pests controlled

Bacterial and fungal diseases
Armyworm
Hairy leaf-caterpillar
Rice leaf roller
Rice stem borer
Semi-looper

Copper spray (Bordeaux mix)

Method of preparation

Mix 3 ½ tbsp of copper sulphate, 10 tbsp of hydrated lime and 1 gallon of water (4 liters of water) in a plastic bucket
Stir using wooden stick

Pests controlled

Flea beetles
Anthracnose
Bacterial blight
Bacterial wilt
Black spot
Downy mildew
Late blight
Powdery mildew
Rust
and many other disease causing pathogens

Cautions

Use only plastic containers
Shake or stir to prevent extract from clogging
Spray only on dry and sunny day, preferably early morning

Late blight

Symptoms

Newly infected leaves have dark-green watersoaked small lesions (spots), and as the lesions grow, they appear as brown spots, with each spot surrounded by a yellow green margin. A closer look at the leaf margin will show where the fungus is most active and how it spreads on the leaf tissues. There is a halo (ring) of white spore producing structures that is found in the margin of the advancing lesion on the underside of the leaf. The parts of the veins passing through these lesions turn brownish. As the infection spreads, more brown spots appear causing the whole plants to blacken and die.

The infected stem has also brown to black irregular spots that destroy the emergence of new shoots at various growing points.



Infested young fruit has brown bumps with lesions that are large, irregular, and greenish-brown patches with a greasy rough appearance. Infected fruits never reach maturity.

Severely infected tomato plant has a distinctive odor as a result of the rapid breakdown of the leaf tissues.

Prevention and control

1. *Aloe and Vitex extract* (refer to p. 29)
2. *Basil leaf extract* (refer to p. 25)
3. *Baking soda*
4. *Compost tea spray* (refer to p. 26)
5. *Fermented Marigold extract* (refer to p. 29)

Baking soda

Method 1
Mix 1 tbsp of baking soda and 1 tbsp of dormant oil or vegetable oil
Add 4 liters of water
Stir well
Add ½ tbsp of dish washing liquid soap
Stir it again

Method 2
Dissolve 1 tbsp of baking soda in 4 cups of warm water
Add 1 tsp of liquid soap
Stir well

Method 3
Mix 1 tbsp of baking soda and 2 ½ tbsp of vegetable oil
Add 4 liters of water
Stir well

Diseases controlled

Powdery mildew, black spot, and other fungal diseases

Leaf curl virus



Symptoms

Infected plant has stunted young leaves and shoots. It grows very slowly, becomes bushy, and dwarfed. The leaf margin rolls either inward or upward and is rather stiff with yellowish margin. Its leaves are thicker than normal, with leathery texture. The young leaves have yellowish color, cupped, thick, and rubbery.

Prevention

1. Control whiteflies as they are the carriers of the disease
2. Do not plant tomato near areas where other solanaceous crops and cotton are planted and known to be infested by whiteflies.
3. *Compost tea spray* (refer to p. 26)

Powdery mildew

Symptoms

Powdery mildew is characterized by a dusty-white to gray coating and talcum powder-liked growth commonly infecting plant's leaves. It begins as circular, powdery-white spots that turn yellow-brown and finally black. In most cases, the fungal growth can be partially removed by rubbing the leaves.

Powdery mildew is commonly found on the upper side of the leaf. It also infects the underneath surface of the leaf, young stem, bud, flower, and young fruit. The infected leaf becomes distorted, turns yellow with small patches of green, and falls off prematurely. Infected buds fail to open. Other injuries include stunting and distortion of leaves, buds, growing tips, and fruits. Infected seedlings will eventually die.

Prevention and control

1. *Baking soda* (refer to p. 30)
2. *Basil leaf extract* (refer to p. 25)
3. *Compost tea spray* (refer to p. 26)
4. *Copper Spray (Bordeau Mix)* (refer to p. 29)
5. *Ginger powder extract*
6. *Milk spray* (refer to p. 18)
7. *Papaya leaf extract*

Ginger powder extract

Method of preparation

Add 20 g of ginger powder to 1 liter of water
Mix thoroughly

Diseases controlled

Powdery mildew
Root rot
Fungal leaf blight

Papaya leaf extract

Method of preparation

Soak 50 g of finely shredded leaves in 1 liter of water. Let it stand for 1 night.
Squeeze the extract and strain. add 2-3 liters and 10 ml soap as adhesive.

Diseases controlled

Leafy caterpillars
Coffee rust
Leaf rust
Mosaic virus
Powdery mildew

Tomato mosaic virus

Symptoms

The common symptom of an infected plant is alternating spots of yellowish and light or dark green (mottle) leaves. The mottled areas often appear thicker and somewhat elevated giving the leaves a blister-like appearance. Other symptoms include curling and yellowing of the leaves, stunted growth, and malformed fruits.

Prevention

1. Control aphids and other sucking insects as they carry the virus.
2. *Milk spray* (refer to p. 18)

For seed treatments

Sweetflag rhizome

Method of preparation

Pound or grind dried sweetflag rhizome. Take 10 g sweetflag rhizome powder and add 60 ml of water.
Soak seeds for 30 minutes
Sow treated seeds immediately

Vinegar solution

Mix 1 tbsp of vinegar and 4 cups of water
Place the seeds on a small cotton bag
Dip the bag into the vinegar and water solution
Dry dipped seeds on old newspapers before sowing and make sure that seeds are completely dry before storing

Natural enemies

Braconids



Hosts

Ants, aphids, armyworms, beetle's larvae, bollworms, cabbageworms, caterpillars, codling moths, corn borers, cutworms, imported tent caterpillars, leafhoppers, leafminers, maggots, midges, plant bugs, scales, tomato hornworms, weevils, and many more.

Description

Eggs and larvae of Bracons are found inside the hosts' bodies. The larvae are tiny, cream-colored grubs that feed in or on other insects. Larvae molt five times and undergo 5 instars.

Pupae of some species live and pupate within the host until they mature; others pupate in silken cocoons on the outside of the body of the host, while others spin silken cocoons away from the host.

Adult wasps are tiny, about 2.5 mm in size, slender black or brown with threadlike waists. Female wasps lay eggs into the eggs of hosts' pests but prefer caterpillars' bodies.

In cases where aphids are the host pests, aphids are not killed instantly. Aphids continue to feed on plants tissues until the Braconid larvae inside their bodies completely consume them. The fully-grown Braconid larvae cement the dead aphids to the leaf surface making aphids' shells black and mummified. About a week later, the adult Bracon wasps cut round holes in the mummies and emerge. The empty mummies remain on the leaf. The presence of mummies in a colony of aphids is a sign that Bracons are present.

Conservation

Adult Bracons feed on nectar, honeydew, or pollen before laying eggs. Dill, parsley, yarrow, zinnia, clover, alfalfa, parsley, cosmos, sunflower, and marigold are flowering crops that attract the native braconid populations and provide good habitats for them.

Damsel bugs



Hosts

Aphids, armyworms, asparagus beetle, Colorado potato beetle eggs and nymphs, corn earworm, corn borer, imported cabbageworm, leafhoppers, mites, moth eggs, sawfly larvae, and tarnished plant bug nymphs. Although they can survive for about two weeks without food, they will eat each other if no other prey is available.

Description

Eggs are deposited in soft plant tissues where they are so difficult to find.

Nymphs resemble adults and develop through 5 nymphal stages in about 50 days.

Adults are tiny, about 2-4 mm long, with slender bodies and are yellowish or gray or reddish-brown in color. They have piercing-sucking mouthparts, a 4-segmented beak, elongated heads, and 4 long segmented antennae. They are fast runners with long slender back legs and enlarged forelegs for grasping prey. They are commonly found in most agricultural crops, especially legumes, throughout the year. Adults begin laying eggs soon after emergence.

Conservation

They prefer to live in soybeans, grassy fields, and alfalfa. You can collect damsel bugs in alfalfa fields and release them around your garden.

Encarsia

Hosts

Various whitefly species

Description

Eggs are found inside the body of the host larva. The larvae develop within the whitefly larvae passing through four larval stages. The host pupa turns black when Encarsia pupates inside the whitefly. Adult wasps emerge from the parasitized pupae by chewing a hole in the top of the scale. Adults are very tiny wasps, about 1 mm in size. These parasitic wasps can look actively and effectively for whiteflies. They can cover distances of 10-30 m looking for hosts. Adult females attack young whitefly larvae by stinging and laying eggs inside them. An adult female wasp can lay 60-100 eggs. The life cycle is completed within 2-4 weeks depending on the climatic conditions. Adults can live for 30 days but are active for about 10 days. Adult wasps feed on honeydew and the body fluids of whitefly larvae. They also feed directly on the scales. However, honeydew restricts their movements so that it is difficult for them to have a wider feeding coverage. With the exception of the adult, all stages of Encarsia occur inside the whitefly host.

Conservation

Conserving natural enemies is probably the most important practice farmers could do. Practicing multiple cropping (including flowering crops) provides pollen, honeydew, and nectar for adult wasps. The practice can increase the diversity of habitats that provide shelter and other food sources to the natural enemies.

Some Encarsia species are native to crop production environments. When introduced, they have the tendency to adapt to the local environments.

Weekly field monitoring or a visual inspection of plants is important to notice the presence of pests and beneficial insects in order to consider when to make pest management decisions.

Ground beetle



Hosts

Slugs, snails, cutworms, cabbage root maggots, grubs and insect pupae, and small caterpillars

Description

Eggs are normally laid singly in the soil.

Larva is elongated and tapered toward the end, worm-like in appearance and have a large head directed forward.

Pupa is brownish black, small and found in the soil.

Adult ground beetles or Carabids are about 2-6cm long, dark shiny brown to metallic black, blue, green, purple, or multi-colored. They vary in shapes,- from elongated to heavy-bodied, - tapered head end with threadlike antennae, and have a ringed wing cover. Their heads are usually smaller than their thorax. Both adults and larvae have strong pincher-like mandibles. They have prominent long legs, which make them fast moving insects. Most species are nocturnal and they hide during the day in soil crevices, under rocks and stones, decaying logs, leaf litter, or composting materials. When disturbed or when other vertebrates prey upon them, they emit an odor or gas, as a type of defense mechanism, preventing them from being eaten by other predators. Ground beetles live on or below the ground, hence the name. Development from the egg to the adult stage takes about a year, although adults may live 2 to 3 years or longer.

Conservation

1. Practice mulching in some sections of your field to provide a habitat for the ground beetles.
2. Provide permanent beds and perennial plantings to protect population.
3. Plant white clover and/or amaranth as ground covers.

Hoverfly



Hosts

Aphids, thrips, psyllids, scale insects, small caterpillars, and larvae of Heliotes

Description

Eggs are tiny, about 1mm in size, ovate-shaped, and glistening white. These are found laid singly and close to the developing aphid colony in the leaves, shoots, or stems of the plants. They hatch within 2-3 days.

The larvae, known as Syrphids, are legless slug like maggots, about 1-13mm in length depending on their larval stages. They usually have a mottled gray, beige, or light green color. They lift their pointed heads to look for preys. Once preys are located, their mouthparts suck out the contents of the preys. Larvae are frequently found feeding on aphids in the sheltered and curled portion of leaves. They blend well with their habitat and therefore they must be looked for closely to locate them.

Pupae are teardrops shaped and are found in the soil surface or in the plant's foliage.

Adult hoverflies are true flies with only two wings instead of four which most insects have. Adults are large and beautiful insects about 13 mm long. They have a dark head, a dark thorax, and a banded yellow and black abdomen. They closely resemble bees or wasps rather than flies. Their habit of hovering like humming birds gave them the names hoverflies or flower flies. They feed on pollen, nectar, and honeydew. They are good pollinators.

Conservation

Hoverflies are attracted to all flowering plants but even more so to small-flowered herbs like wild mustard, coriander, dill, lupines, sunflower, and fennel. It is advisable to have multiple crops as adults basically feed on pollen and nectar and it is advisable to allow flowering weeds such as wild carrot and yarrow to grow between crop plants. Hoverflies' larvae are most noticeable in the latter half of the growing season when aphids are established.

Lacewing

Hosts

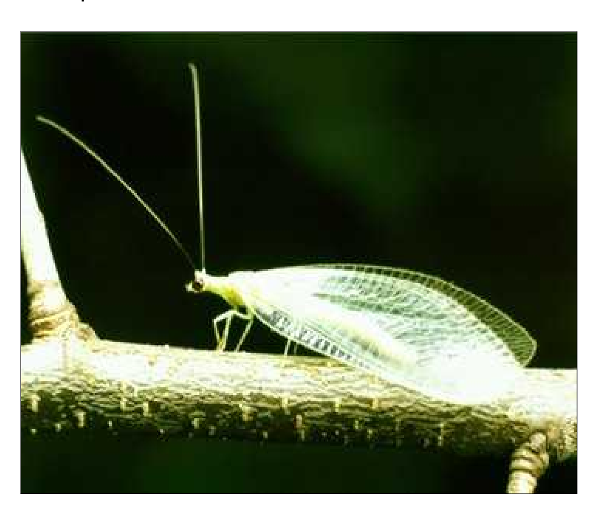
Aphids, leafminer, mealybugs, thrips, whitefly, armyworms, bollworms, cabbage worm, codling moths, corn borer, cutworm, DBM, fruitworm, leafhopper nymphs and eggs, potato beetle, scale insects, spider mites, and caterpillars of most pest moths. If given the chance, they can also prey on adult pests.

Description

Eggs are found on slender stalks or on the underside of leaves. Each egg is attached to the top of a hair-like filament. Eggs are pale green in color.

Larvae are known as aphid lions. Newly hatched, they are grayish-brown in color. Upon emerging, larvae immediately look for food. They grow to about 1 cm in length. They attack their prey by taking them with their large sucking jaws and injecting paralyzing poison, and then sucking out the body fluids of the pest. A larva can eat 200 or more pests or pest eggs a week. An older larva can consume 30-50 aphids per day. It can consume more than 400 aphids during its development. The larvae resemble alligators with pincers like jaw. However, they become cannibalistic if no other prey is available. They feed for 3 to 4 weeks and molt three times before pupation. They cover their bodies with prey debris.

Pupae are cocoons with silken threads. These are found in cracks and crevices. The pupal stage lasts for approximately 5 days.



Adults are green to yellowish-green with four, delicate transparent wings that have many veins and cross veins. Adults are about 18 mm long, with long hair-like antennae and red-gold eyes. Each adult female may deposit more than 100 eggs. Many species of adult lacewings do not prey on pests. They feed on nectar, pollen, and honeydew. An adult will live for about four to six weeks depending on the climatic conditions.

Conservation

Flowering plants such as dill, cosmos, sunflower, carrots, and dandelions are good source of pollen and nectar for adults. Provide source of water during dry season.

Ladybird beetles

Hosts

Aphids, mealybugs, scale insects, spider mites, whiteflies

Description

Eggs are yellow to orange in color, football-shaped, and are laid in circular clusters of 10 -50 eggs on the underside of leaves or near the aphid colony.

Newly hatched larvae are gray or black and less than 4 mm long. They emerge as dark alligator-like flightless creatures with orange spots. Adult larvae can be gray, black, or blue with bright yellow or orange markings on the body. The larvae are elongate and slightly oblong in shape. They undergo four instars before pupating.

The pupae are usually brightly patterned and can be found attached to the leaves and stems of plants where larvae have fed and developed.

Adults are oval to hemispherical and strongly convex with short legs and antennae. Most species are brightly colored. Body length ranges from 0.8-16 mm. Their colors tell other predators that they are tasteless and toxic. When disturbed, some of them emit a strong smelling yellow liquid as a protection against other predators. Their colors vary from red, orange, steel blue, yellow-brown, or yellow elytra, frequently spotted or striped with black. They feed on pollen, nectar, water, and honeydew but aphids or other prey are necessary for egg production. They are the best-known predators of aphids and are capable of eating up to 50-60 per day and about 5000 aphids in their lifetime.

Conservation

Lady bird beetles are found in most agricultural and garden habitats. Their presence indicates that natural biological control is occurring. It is important to maintain habitats planted with several flowering crops. These give the ladybird beetles varied food sources. When food is not available, they tend to eat each other. Their beneficial predatory behavior and activities are continuous when there is no indiscriminate use of synthetic pesticides.

Rove beetles



Hosts

Both adults and larvae are predators of root maggots' eggs and larvae, mites, worms, nematodes, and other small insects. Adults tend to be cannibalistic, eating their own eggs and attacking other adults when food supply is low.

Description

Eggs are tiny, about 0.5 mm long and 0.4 mm wide, pear-shaped, pale green in color, and are covered with a gelatin-like material. These are laid by female adults in the soil among the roots of the root-maggot infested plants. The eggs hatch 5-10 days later.

The first instar larvae are pale brown, about 1.5 mm long, slender, segmented, and tapered toward the anterior. They have large heads. The parasitic second and third instar larvae are white, have rudimentary legs, and are found within the host puparium. Before pupating, a larva will actively search for a host (pupa of maggot) in the surrounding soil. It will pupate in the pupa of the maggot by entering into its cocoon and feeding its contents, and then pupate itself inside for about 3-4 weeks before emerging as an adult. It is possible that two or more larvae enter into one maggot pupa but only one will survive and mature.

Adult rove beetles are brown, reddish-brown, or black or have gray markings on the wings and abdomen, with slender elongate bodies. Their wing covers are shorter than the abdomen where most part of the abdomen is exposed. Both adults and larvae have well-developed 'jaws' cross in front of the head. They live mostly in decaying organic matter but are also found in moist agricultural soils or in habitats where large numbers of fly larvae live. When disturbed, they run very fast, with their abdomen lifted upward, like that of scorpions. Adults are good fliers as well.

Conservation

Provide ground covers or mulches within and around fields for rove beetles love to stay in moist decaying organic matter; provide hiding sites and alternative habitats and plant flowering borders, hedges, and other perennial habitats as a source of food and shelter; and provide protection by not spraying broad spectrum pesticides.

Spider

Hosts

Moths and caterpillars

Description

Some spiders' eggs are laid in a cluster in silken sacs, while some species lay their egg masses covered with silks within folded leaves. Some of these sacs are attached to the mother spiders or mothers stay nearby to guard their egg sacs. Eggs usually hatch into spiderlings within three weeks. The spiderlings may remain attached to the mother for several days on some species, but for some species they are left on their own.

Spiders are not insects. They have 8 legs while insects have 6. They do not have wings whereas insects do. They have two body sections; a united head and thorax and abdomen, while insects have three; head, thorax, and abdomen.



A female can produce 200-400 eggs but only 60-80 spiderlings can hatch from these. Females can survive 2-3 months. In some species, females die after laying eggs.

All spiders are poisonous to insects but only a few species are poisonous to humans, like the Black widow and the Brown recluse.

Conservation and management

Mulching along some sections in dikes of rice paddies, in field corners, or a portion of the fields can increase the number of spiders. They can hide in the layer of mulch that serves as their alternate habitat. They can also prey on other small insects inside the mulch.

Remember, that the more food the spiders can eat, the faster their population build-up will become.

Cover crops are also important to provide over-wintering sites of spiders' sacs.

A spider population depends on the availability of food, the habitat, and the environmental conditions. Avoid use of pesticides as much as possible, for broad-spectrum insecticides can easily kill them.

Tachinid fly



Hosts

Aphids, armyworm, beetles, bollworm, bugs, cabbage looper, cotton stainer, cutworm, grass-hoppers, hornworm, leafhoppers, mole crickets, moths, sawflies, scale insects, stem borers, stick insects.

Description

Eggs are ovate-shaped and white in color. They are found in the skin of the host insect or in leaves near the host and are hatched when the host ingests them.

The larvae or maggots are worm-like and lack appendages like all other fly larvae. They are greenish-white in color. They have three larval instars and then leave the hosts to pupate in the soil. Before pupation, some mature maggots produce hard cocoons. The larval stage takes about 4 days to 2 weeks depending on the climatic conditions. The newly hatched larvae enter into its host and feed on the content before pupating into the soil. Some tachinid species are hosts' specific, for example for a certain species; it is parasitic only on leaf rolling caterpillars, or only on sugarcane stem borer.

Pupae are oblong, yellowish and turn dark-reddish as they mature.

Adults measure between 3 and 10 mm and have very stout bristles at the tips of their abdomens. They look very similar to the common housefly but are larger with stocky and soft bodies. They vary in appearance from gray black to brightly colored, or sometimes looking like bees. Adult Tachinid flies have only 1 pair of wings. They feed on honeydews and flower pollen. Different species have varied modified sucking type mouthparts: the cutting sponging, the piercing-sucking, and lapping-sponging. Adult flies are found in almost all crop habitats, either resting on foliage or feeding on nectars and pollen. Additionally for females, they search for hosts to lay their eggs. The female adult lays her eggs near or into the larvae, or on another insect. She can lay as many as 1000-2000 eggs in her lifetime. Adults can live from 3 days to 2 months depending on the species.

Conservation

Providing sources of food like dills, parsley, clover and other herbs are the most efficient ways to conserve Trachinid flies in the agricultural ecosystems.

Trichogramma



Hosts

Trichogramma species parasitize eggs of over 200 species of moth and caterpillars. Among these are; the rice and corn stem borer, cabbageworm, tomato hornworm, *Heliotis* and *Helicoverpa* species, codling moth, cutworm, armyworm, webworm, cabbage looper, fruit worms, and sugarcane borer.

Description

Trichogramma adults are extremely small. The female adult lays her eggs on other moths' eggs. First, she examines the eggs by antennal drumming, then drills into the eggs with her ovipositor, and lays one or more eggs inside the moth's eggs. She usually stays on or near the host eggs until all or most of them are parasitized. When the parasitized moth's eggs turn black, the larvae parasites develop within the host eggs. The larva eats the contents of the moth's eggs. Adults emerge about 5-10 days later depending on the temperature. Adults can live up to 14 days after emergence. Female adults can lay up to 300 eggs.

Conservation and management

Trichogramma species differ in their searching behavior, host preferences, response to environmental conditions, and suitability in biological control uses. The timing of Trichogramma releases in the field is important. Non-parasitism could be due to the use of less suitable Trichogramma strains to the host pests, environmental conditions, and untimely release of parasitoids. It is best to release of parasitoids at the beginning of a pest infestation (when moths are first seen in the field), followed by regular releases until a natural breeding population of Trichogramma is established.

An example of this approach is the corn borer control. The first release should be during the first appearance of moths and corn borers' eggs in the cornfields. Weekly releases thereafter are to ensure the Trichogramma population build-up and parasitism occurrence. The build-up of the parasitoids depends on the presence of the pest or alternative hosts and food for adults. It is important to regulary monitor pest population, egg parasitism (parasitized eggs are black in color), and the larval infestation. Trichogramma are released as pupae in parasitized host eggs. The pupae can be pasted on cards or put in various containers. To be successful in the field, food, host eggs and shelter must be available.

Modify cropping practices by practicing crop rotation and by planting cultivars which are favorable to Trichogramma population build-up such as wild carrots, dill, golden rod, leguminous plants, and flowering vegetables. Adults feed only on nectar, pollen, and honeydew. Many of these species are found naturally occurring in agricultural and garden habitats. Many adult parasitoids and predators benefit from sources of nectar and the protection provided by refuges such as hedgerows, cover crops, and weedy borders. Avoid indiscriminate use of hazardous pesticides to ensure their presence in agricultural fields.

Photo credits

page

01 Tomato plant. PixelQuelle.de
10 Ants. Takumasa Kondo
11 Aphids. University of Florida. http://mrec.ifas.ufl.edu/lso/Aphids.htm
12 Cutworm. Clemson University. http://entweb.clemson.edu/cuentres/eiis/factshot/pages/Cutworm.htm
13 Flea beetles. Texas A&M University
14 Hornworm. Texas A&M University, http://vegipm.tamu.edu/chewing4/tomatohornworm.html
15 Leafhopper. Photo courtesy of Ric Bessin, University of Kentucky
16 Leafminers. Koppert Biological Systems. http://www.koppertonline.com/showitem.asp?vis=home&item=pest&id=29
17 Psyllids. OMAF. http://www.gov.on.ca/OMAFRA/english/crops/facts/potato_psyllid.htm
18 Spider mite. Texas A&M University. http://insects.tamu.edu/fieldguide/cimg371.html
19 Thrips. Canola Council of Canada. http://www.canada-council.org/slides/pests/insects/html#
20 Tomato fruitworm. Courtesy of INRA, http://www.inra.fr/Internet/Produits/HYPPZ/IMAGES/7031871.jpg
21 Whiteflies. Photo courtesy of Clemsom University - Department of Entomology
22 Wireworm. Texas A&M University.
23 Slug. Photo courtesy of Florida University
24 Common garden snail. Photo courtesy of Florida University
26 Alternaria leaf spot. Texas A&M University. http://aggie-horticulture.tamu.edu/tomatoproblemsolver/ripefruit/8a.html
26 Anthracnose. Janna Beckerman
28 Early blight. University of Minnesota http://www.extension.umn.edu/projects/yardandgarden/ygbriefs/p256earlyblight-pot-tom.html
30 Late blight. Beth Jarvis, University of Minnesota.
31 Leaf curl virus. DEFRA. http://www.defra.gov.uk/planth/pestnote/yellow.htm
33 Braconid. IRRI & Queensland University. IRRI, Los Banos, Philippines.
34 Damsel bug. University of Georgia. http://www.cpes.peachnet.edu/lewis/1nabid.jpg
35 Ground beetle. IRRI & Queensland University. IRRI, Los Banos, Philippines.
36 Hoverfly. Canola Council of Canada. http://www.canola-council.org/slides/pests/insects/insects.html
37 Lacewing. Photo courtesy of Clemsom University- Department of Entomology
38 Ladybird beetles. Kok, L.; Kok, V. http://www.ento.vt.edu/~kok/Biological_Control/Main_body.htm
39 Rove beetles. Jim Kalisch & Barry Pawson.
40 Spider. IRRI & Queensland University. IRRI, Los Banos, Philippines.
41 Tachinid fly. IRRI & Queensland University. IRRI, Los Banos, Philippines.
42 Trichogramma. Cornell University. http://www.nysaes.cornell.edu/ent/biocontrol/parasitoids/trichogramma_ostriniae.html

Alphabetical list of the mentioned control methods

References

The information and the photos in this field guide are taken from the OISAT PAN Germany website www.oisat.org.

Barker, G., Editor. (2002): Molluscs as crop pests. CABI Publishing. CAB International, Wallingford, UK.

Brooklyn Botanic Garden. (2000): *Natural disease control: A common-sense approach to plant first aid.* Handbook # 164. Brooklyn Botanic Garden, Inc. 1000 Washington Avenue, Brooklyn, NY.

Brooklyn Botanic Garden. (1999): *Natural insect control: The ecological gardener's guide to foiling pests.* Handbook # 139. Brooklyn Botanic Garden, Inc. Washington Avenue, Brooklyn, NY.

Bureau of Plant Industry. (1994): *Trichogramma. Manual for farmers' training.* Department of Agriculture. Manila, Philippines.

CABI. (2004): *Crop Protection Compendium, 2004 Edition.* CAB International Publishing. Wallingford, UK.

CABI. (2000): *Crop protection compendium.* 2nd edition, CABI Publishing. Wallingford, UK.

Cremlyn, R. (1978): *Botanical insecticides in pesticides preparation and mode of action.* John Wiley and Sons, NY. pp. 39-49

Ellis, B.; Bradley, F. (1996): *The organic gardener's handbook of natural insect and disease control.* Rodale Press. Emmaus, Pennsylvania.

Gilberg, L. editor. (1993): *Garden pests and diseases.* Sunset books. Sunset Publishing Corporation, California.

Hasse, V. (1987): *Cotton.* No 1-2. Philippine-German Cotton Project, Department of Agriculture. Manila, Philippines

HDRA. (2000): *Diamondback moth, Plutella xylostela.* Pest Control No. TPC3, June 2000 . Tropical Advisory Service. Henry Doubleday Research Association, UK.

HDRA. (2000): *Mexican marigold, Tagetes minuta.* Natural Pesticides No. TNP 2. (June 2000). Henry Doubleday Research Association, UK.

ICIPE. (2003): *Development of environmentally friendly management methods for red spider mites in smallholder tomato production systems...* 2000 - 2003 ICIPE Scientific Report. CD Rom. International Center for Insect Physiology and Entomology, Nairobi, Kenya.

IRRI & Queensland University. (2001): *Rice IPM.* An interactive information and identification system for integrated pest management in rice. University of Queensland and IRRI.

Jayashankar, M.; Subramanian, K.; Arumugasamy, S.; Saraswathy, H.; Vijayalakshmi, K. (2002): *Soil conservation in organic farming.* CIKS. Chennai, India.

Malinoski, M. et al. (2000): *Spider mites.* Integrated Pest Management in Home Gardens. University of California Division of Agriculture and Natural Resources. Pest Notes Publication 7405. p. 2

Mathews, G.; Tunstall, J., eds. (1994): *Insect pests of cotton.* CABI International, UK.

Martineau, J. (1994): *MSDS for Azatin-EC biological insecticide.* AgriDyne Technologies, Inc.

Mochida, O. (1973): *Two important pests, Spodoptera litura and Spodoptera littoralis (Boisduval) on various crops: morphological discrimination of the adult, pupal and larval stages.* Appl. Entomol. Zool. pp. 16-24

Morton, J. (1987): *Custard apple.* In: Fruits of warm climates. Julia F. Morton, Miami, FL.

National Research Council. (1992): *Neem: A tree for solving global problems.* National Academy Press. Washington, DC.

Olkowski, W.; Daar, S.; Olkowski, H. (1995): *The gardener's guide to common-sense pest control.* The Taunton Press. USA.

Olkowski, W.; Daar, S.; Olkowski, H. (1991): *Common sense - pest control.* The Taunton Press. USA.

Parker, B.; Talekar, N.; Skinner, M. (2000): *Field guide: Insect pests of selected vegetables in tropical and subtropical Asia.* AVRDC Publication.

Ploetz, R.; et. al. Editors. (1998): *Compendium of tropical fruit diseases.* APS Press, The American Phytopathological Society. Saint Paul, Minnesota, USA.

Prakash, A.; Rao, J. (1997): *Botanical pesticides in agriculture.* CRC Press. USA.

Reissig, W.; Heinrichs, E.; Litsinger, J.; Moody, K.; Fiedler, L.; Mew, T.; Barrion, A. (1986): *Illustrated guide to integrated pest management in rice in tropical Asia.* IRRI. Los Banos, Laguna, Philippines.

Rossner, J.; Zebitz, C. (1986): *Effect of soil treatment with neem products on earthworms (Lumbricidae).* A paper presented at the Proceedings of the 3rd International Neem Conference, Nairobi, 1986.

Scholaen, S. (1997): *Manejo integral de plagas en hortalizas.* GTZ Eschborn.

Singh, R.; Singh, S. (2000): *Neem for pest management: How to grow and use.* Division of Entomology, Indian Agricultural Research Institute. New Delhi, India.

Sridhar, S.; Arumugasamy, S.; Saraswathy, H.; Vijayalakshmi, K. (2002): *Organic vegetable gardening.* Center for Indian Knowledge Systems. Chennai.

Sridhar, S.; Vijayalakshmi, K. (2002): *Neem: A user's manual.* CIKS, Chennai.

Stoll, G. (2000): *Natural protection in the tropics.* Margraf Verlag. Weikersheim.

Thomas, C. (2002): *Bug vs. bug - crop scouting.* Integrated Pest Management Program. Pennsylvania Department of Agriculture. Harrisburg, PA.

Thurston, D. (1998): *Tropical plant diseases.* Second Edition. APS Press. The American Phytopathological Society. St. Paul, Minnesota, USA.

Tran, L.; Hassan, SA. (1986): *Preliminary results on the utilization of Trichogramma evanescens to control the Asian corn borer Ostrinia furnacalis in the Philippines.* J. Appl. Ent.

Traunfeld, J.; Malinoski, M. (2000): *IPM Series: Tomatoes.* Maryland Cooperative Extension, University of Maryland. Home and Garden Mimeo # HG56. p. 9

Vijayalakshmi, K.; Subhashini, B.; Koul, S. (1999): *Plants in Pest Control: Garlic and onion.* Centre for Indian Knowledge Systems, Chennai, India.

Vijayalakshmi, K.; Subshashini, B.; Koul, S. (1998): *Plants in pest control: Custard apple, vitex, sweet flag, and poison nut.* CIKS. Chennai, India.

Wagner, Georg. (2004): *Vegetables' pests.* Personal Communication. Schopperplatz 14, 4082 Aschach / Donau.



For more information on non-chemical pest management see:

www.oisat.org

Pesticide Action Network (PAN) Germany

Nernstweg 32 • 22765 Hamburg • Germany

Phone: +49 (0)40 - 399 19 10-0 • Email: info@pan-germany.org

Internet: www.pan-germany.org • www.oisat.org